United States Patent [19]

Fikse

[11] **3,966,256**

[45] **June 29, 1976**

[54] **TUNNELING EQUIPMENT**

[75] Inventor: **Tyman H. Fikse**, Enumclaw, Wash.

[73] Assignee: **The Robbins Company**, Seattle, Wash.

[22] Filed: **Apr. 11, 1975**

[21] Appl. No.: **567,269**

[52] U.S. Cl. **299/33**; 61/85; 214/133

[51] Int. Cl.^{2} **E21D 9/08**

[58] Field of Search .... 299/31, 33, 72, 75, 299/70; 173/43; 214/131 A, 133, 1 CM; 198/10; 61/85; 248/179

[56] **References Cited**

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3,578,809	5/1971	Cunningham	299/33
3,612,609	10/1971	Reuls	299/33

Primary Examiner—Ernest R. Purser
Attorney, Agent, or Firm—Graybeal, Barnard, Uhlir & Hughes

[57] **ABSTRACT**

A cutting tool is mounted on the head of a support tripod, the legs of which are double-acting hydraulic cylinders. The rear ends of said cylinders are either pivotally connected to a frame portion of a tunneling machine or to movable barrel portions of three base cylinders having fixed rod portions. The cylinders are selectively extended and retracted for the purpose of moving the cutting tool forwardly and rearwardly and also up and down and sideways.

25 Claims, 16 Drawing Figures

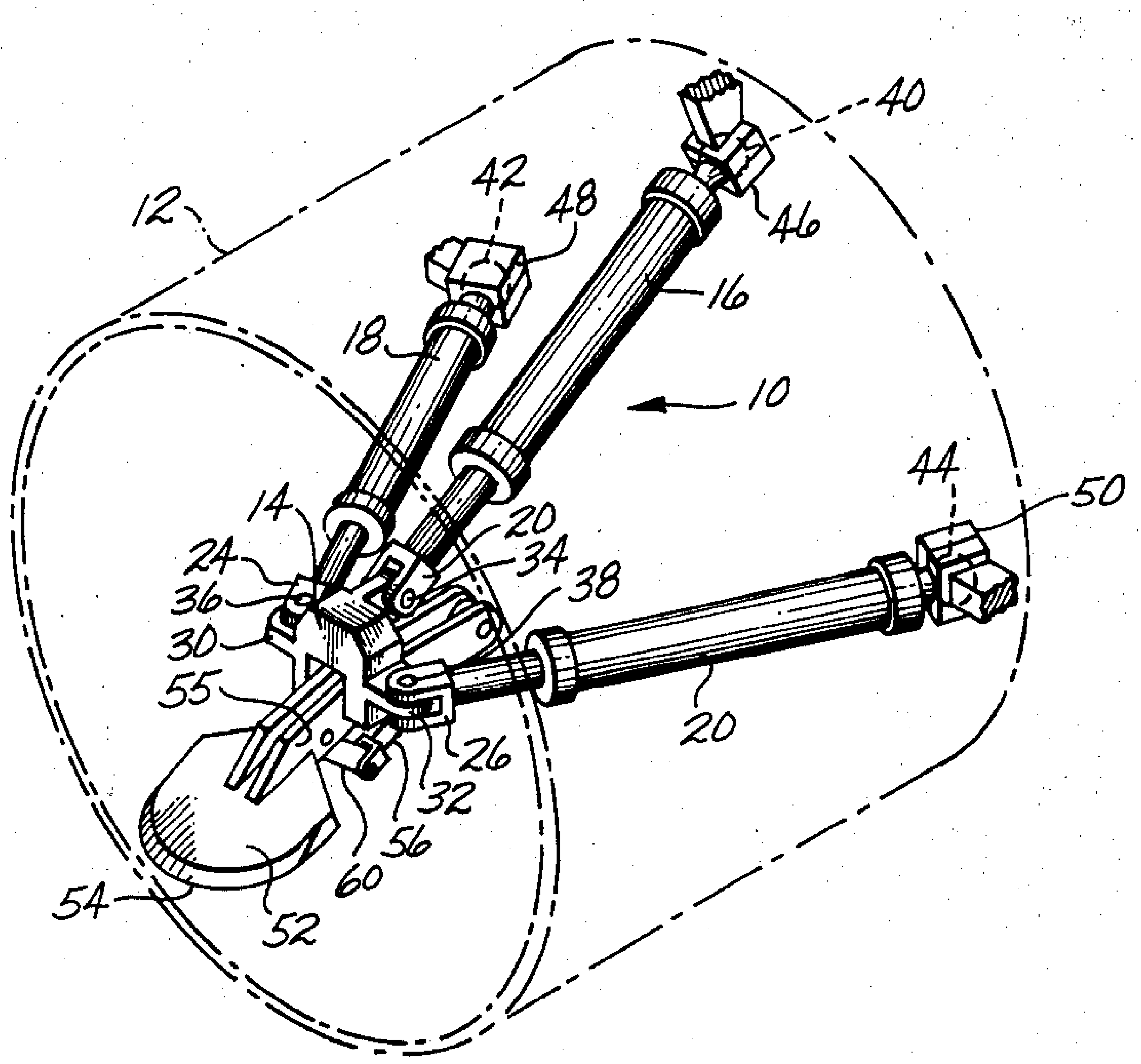


Fig. 1

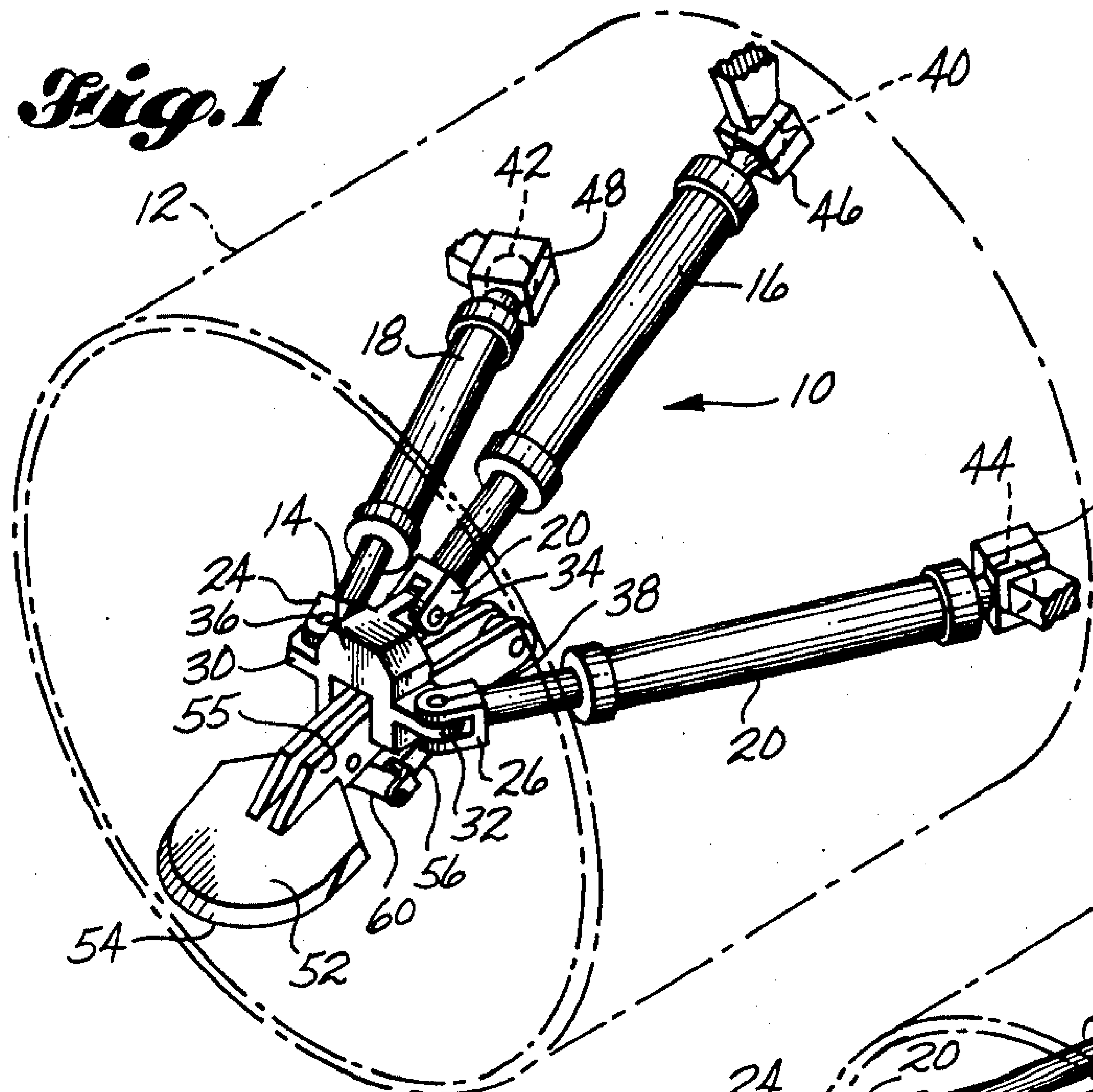


Fig. 2

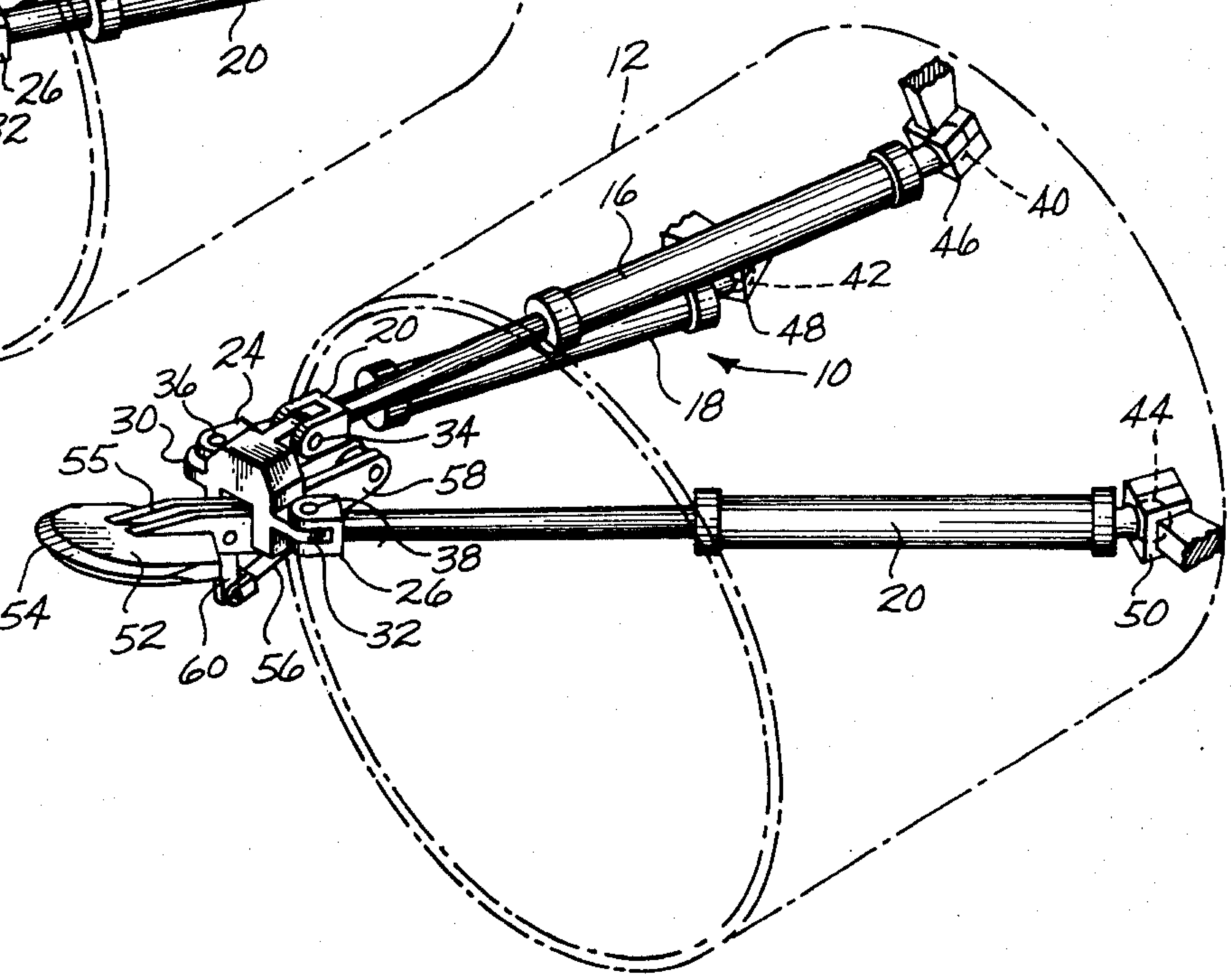


Fig. 3A

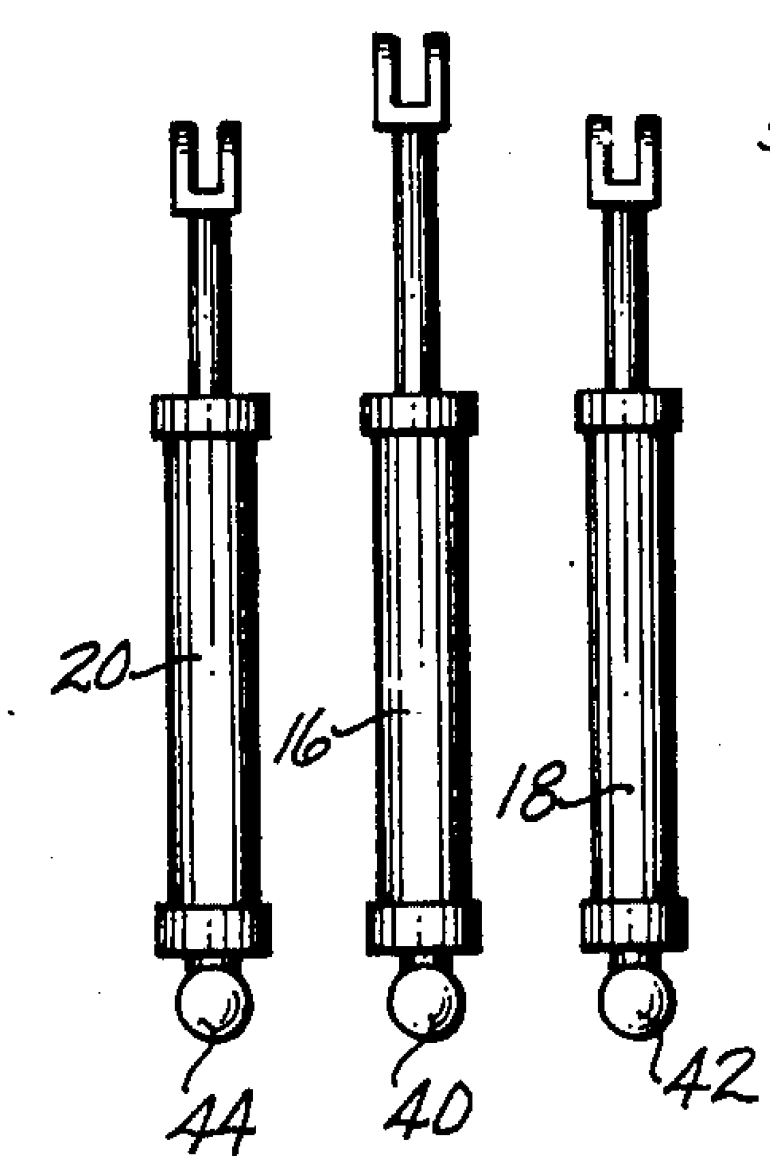


Fig. 3C

Fig. 3D

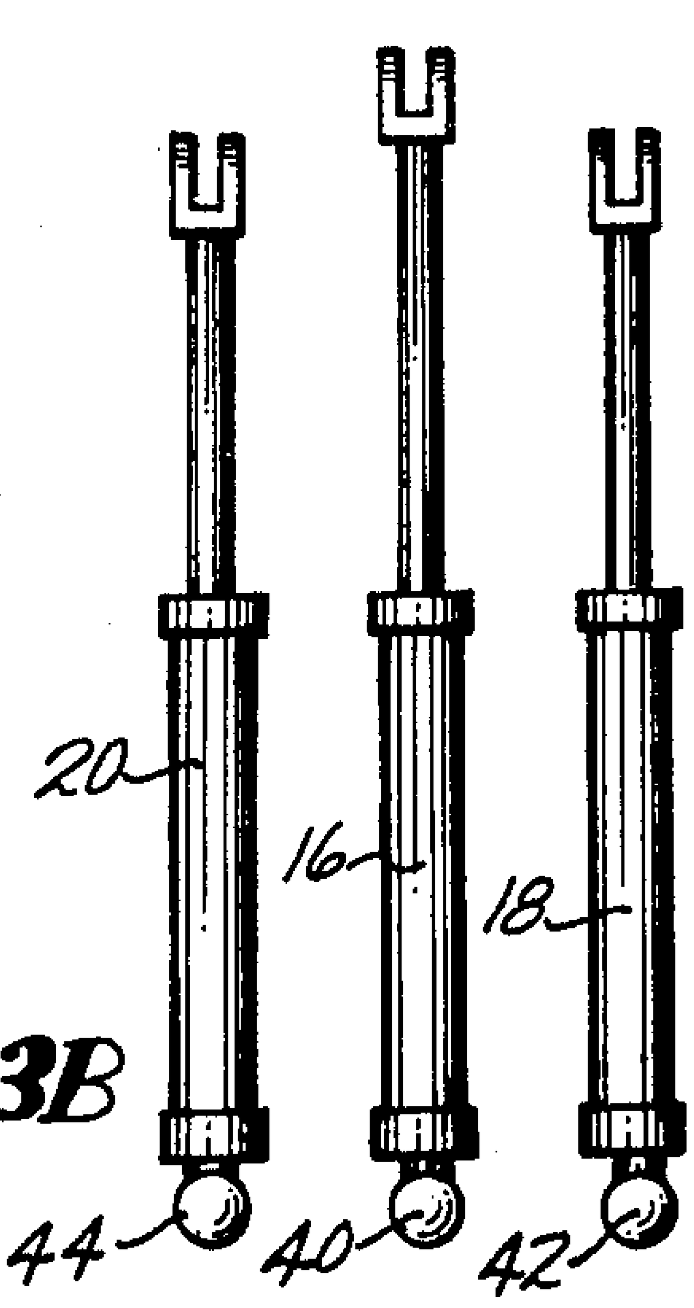
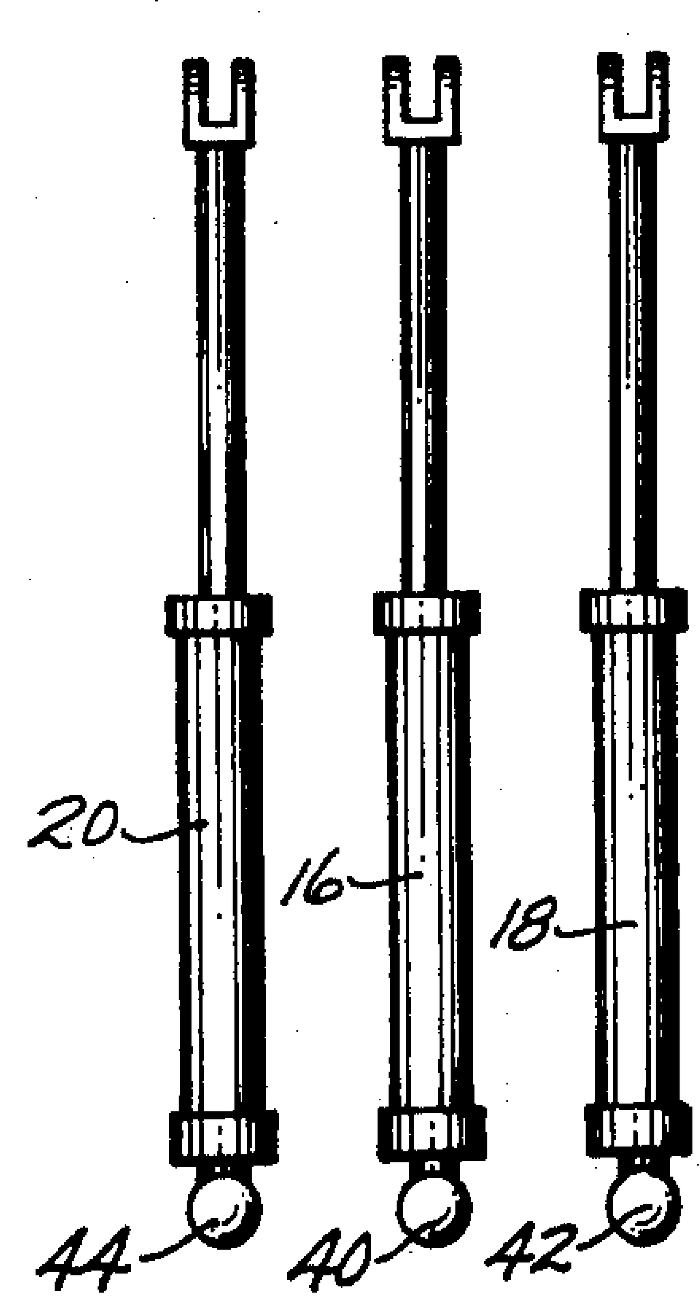


Fig. 3B



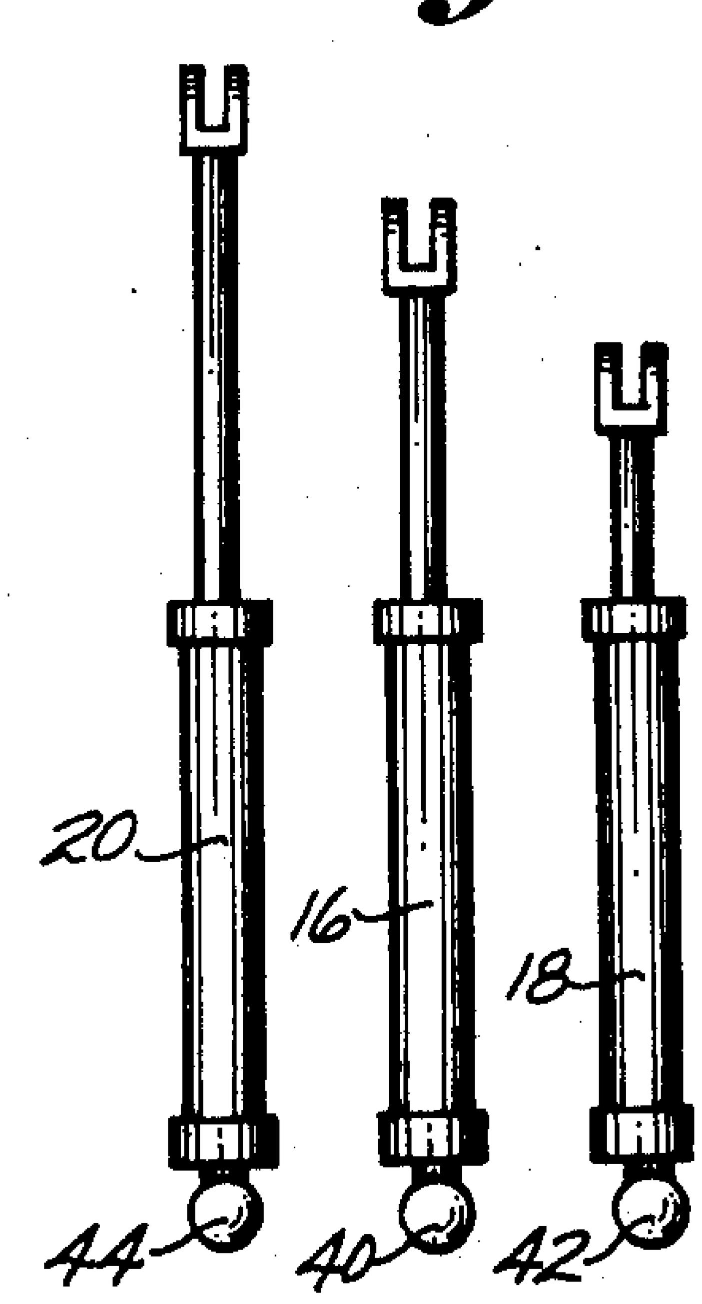


Fig. 1

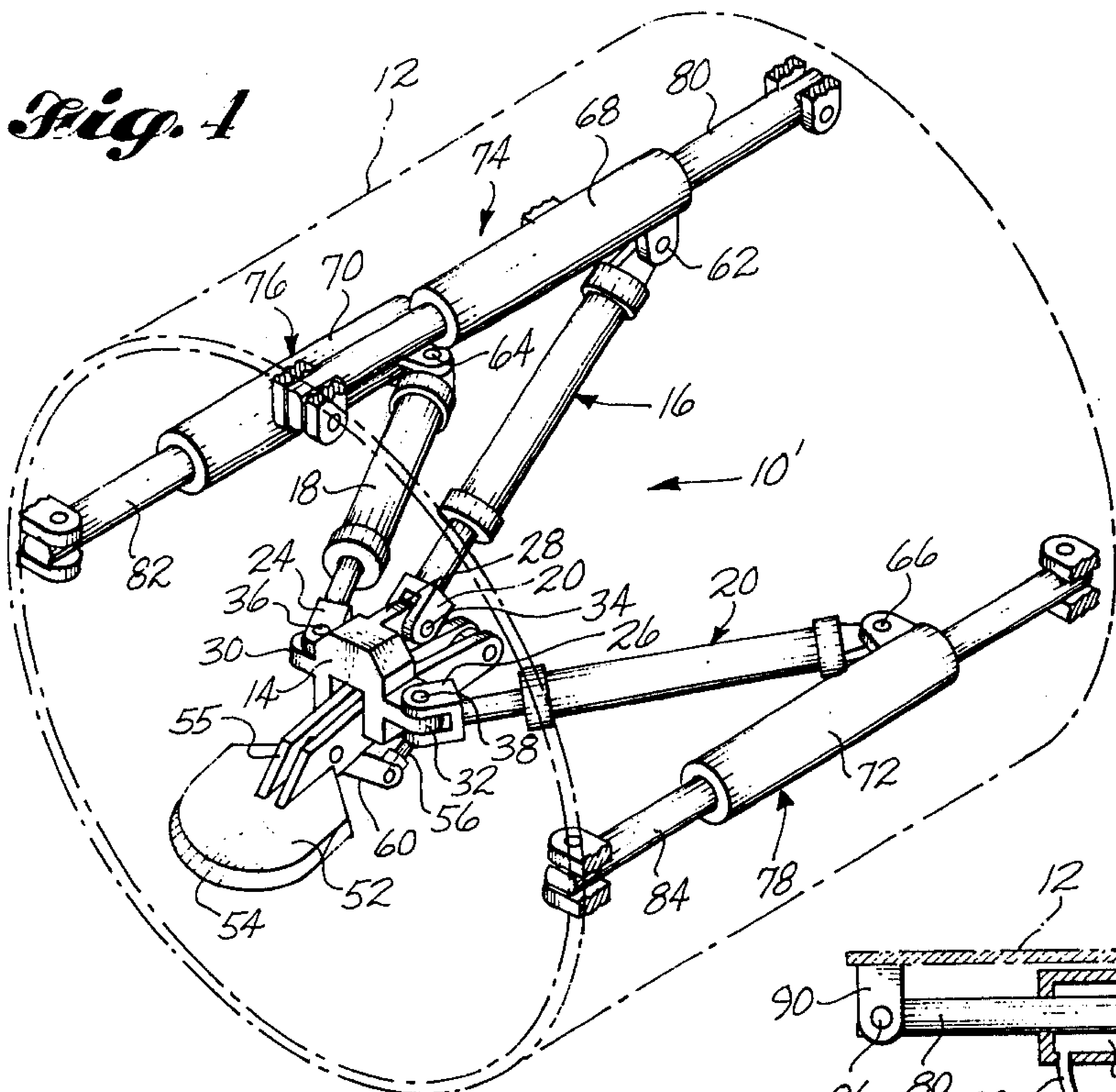
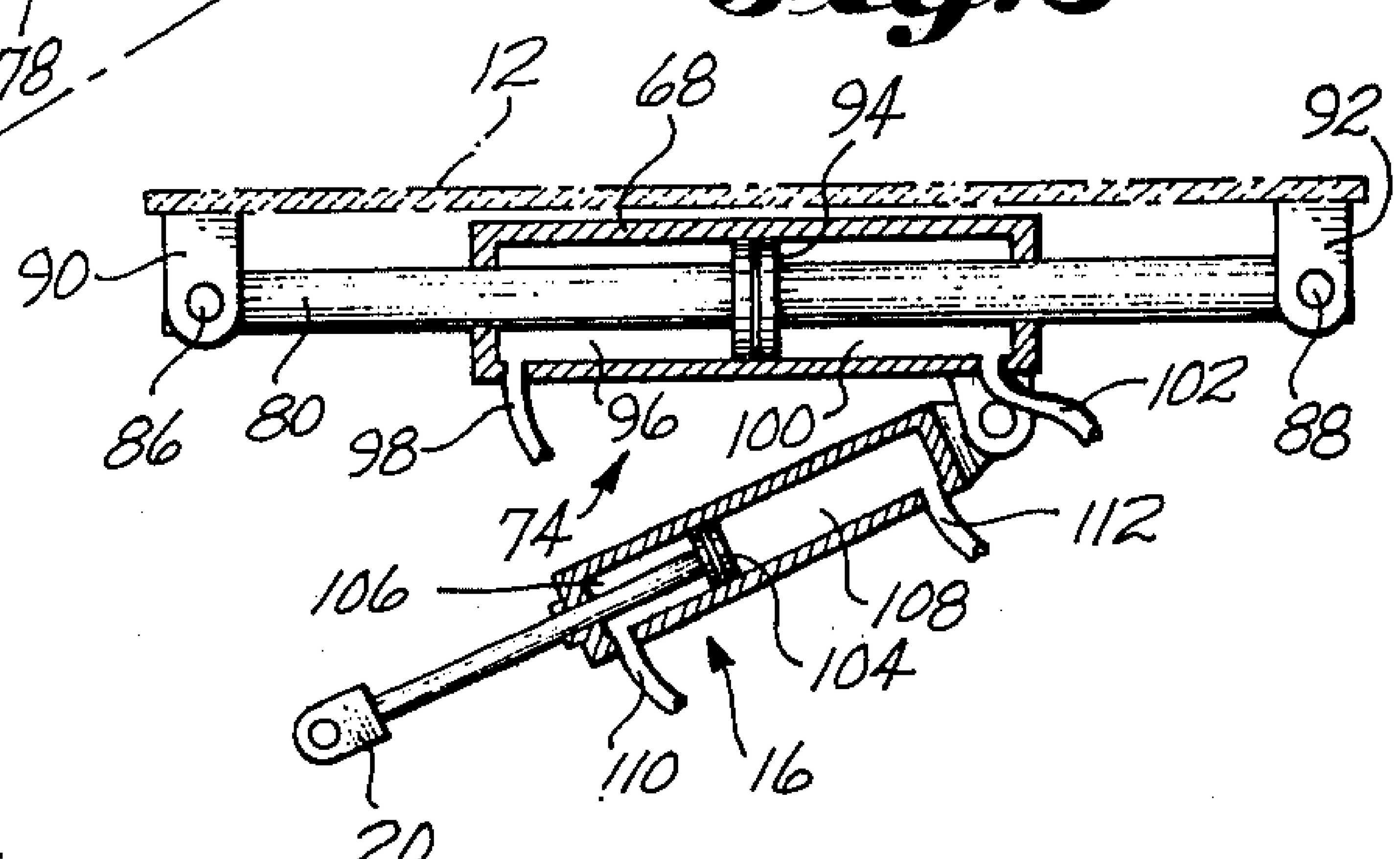


Fig. 5



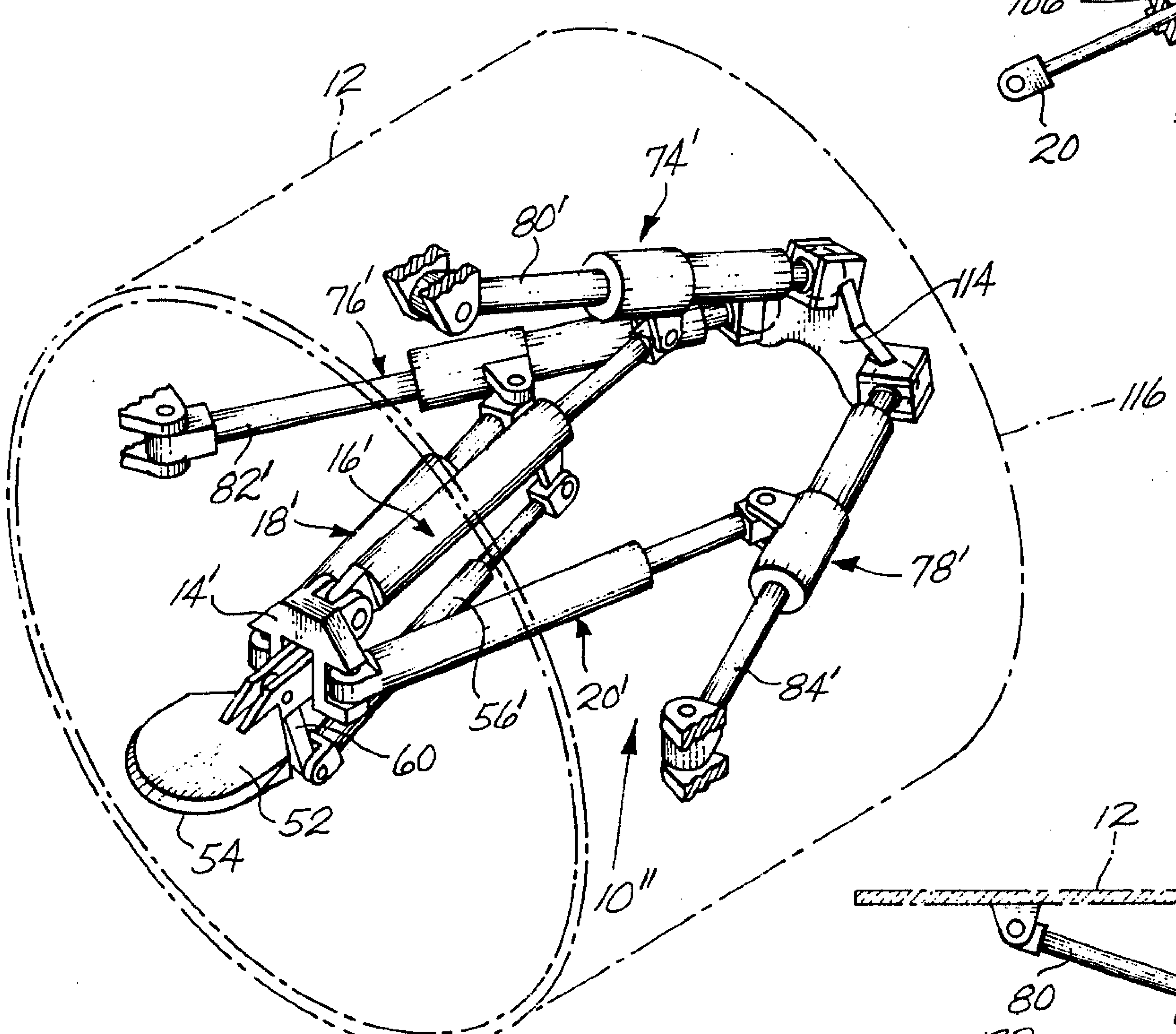


Fig. 6

Fig. 7

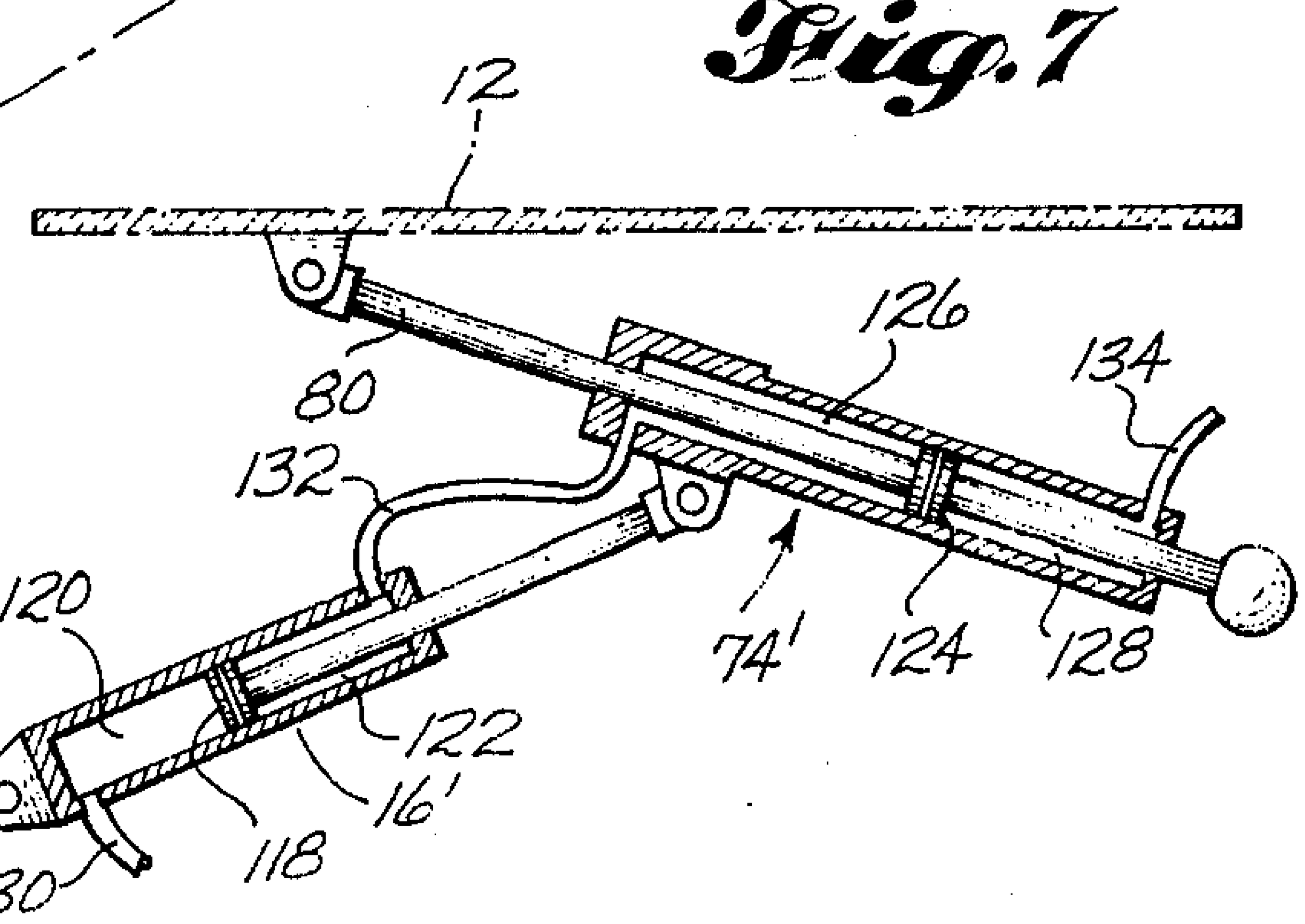
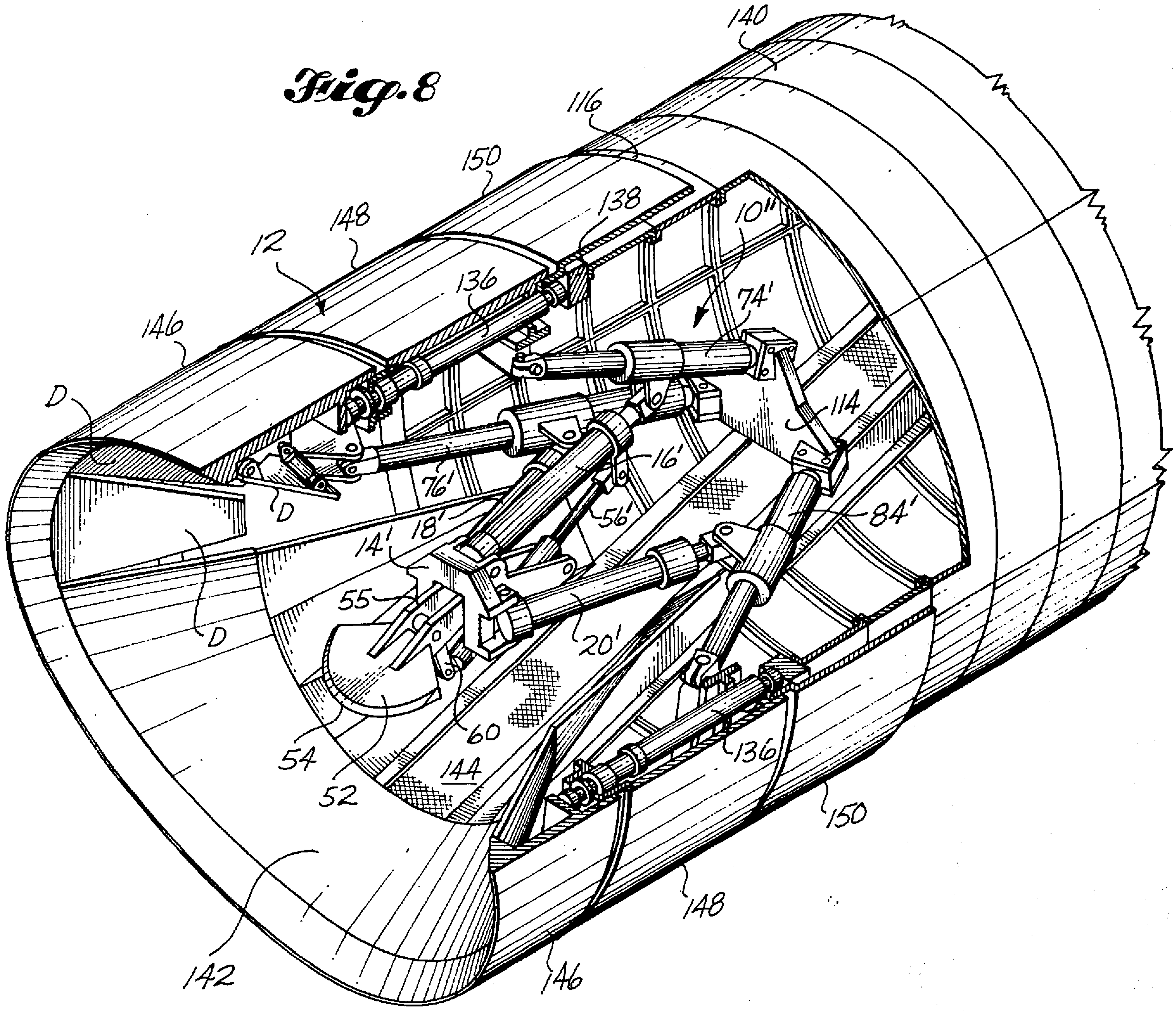


Fig. 8


140
116
150
148
138
12
136
10"
74'
146
D
114
D
76'
16'
18'
56'
84'
14'
55
20'
D
60
136
54
144
52
150
148
142
146

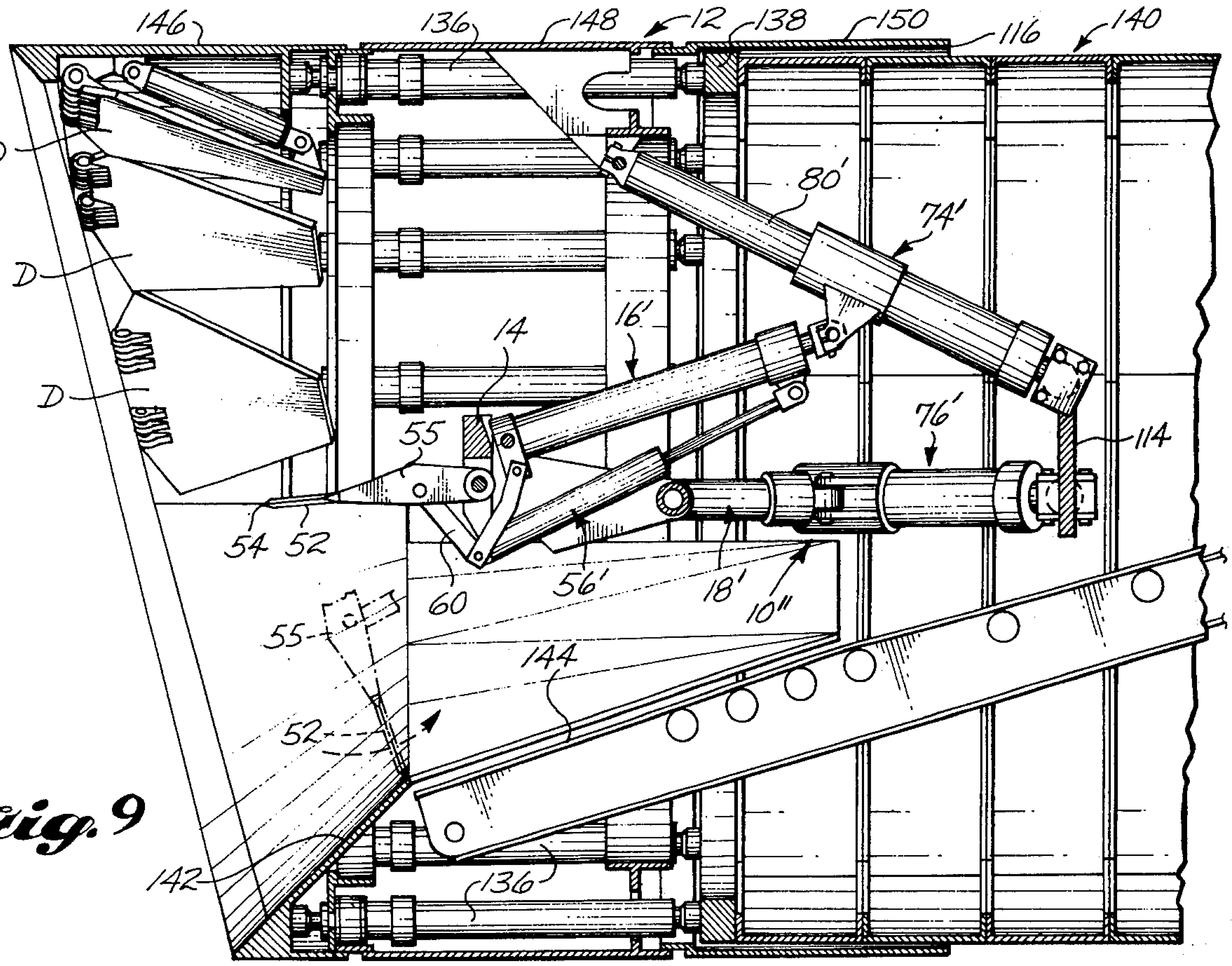

146
136
148
12
138
150
116
140
D
D
D
80'
74'
16'
14
55
114
76'
54 52
60
56'
18'
10''
55
144
52
142
136

Fig. 9

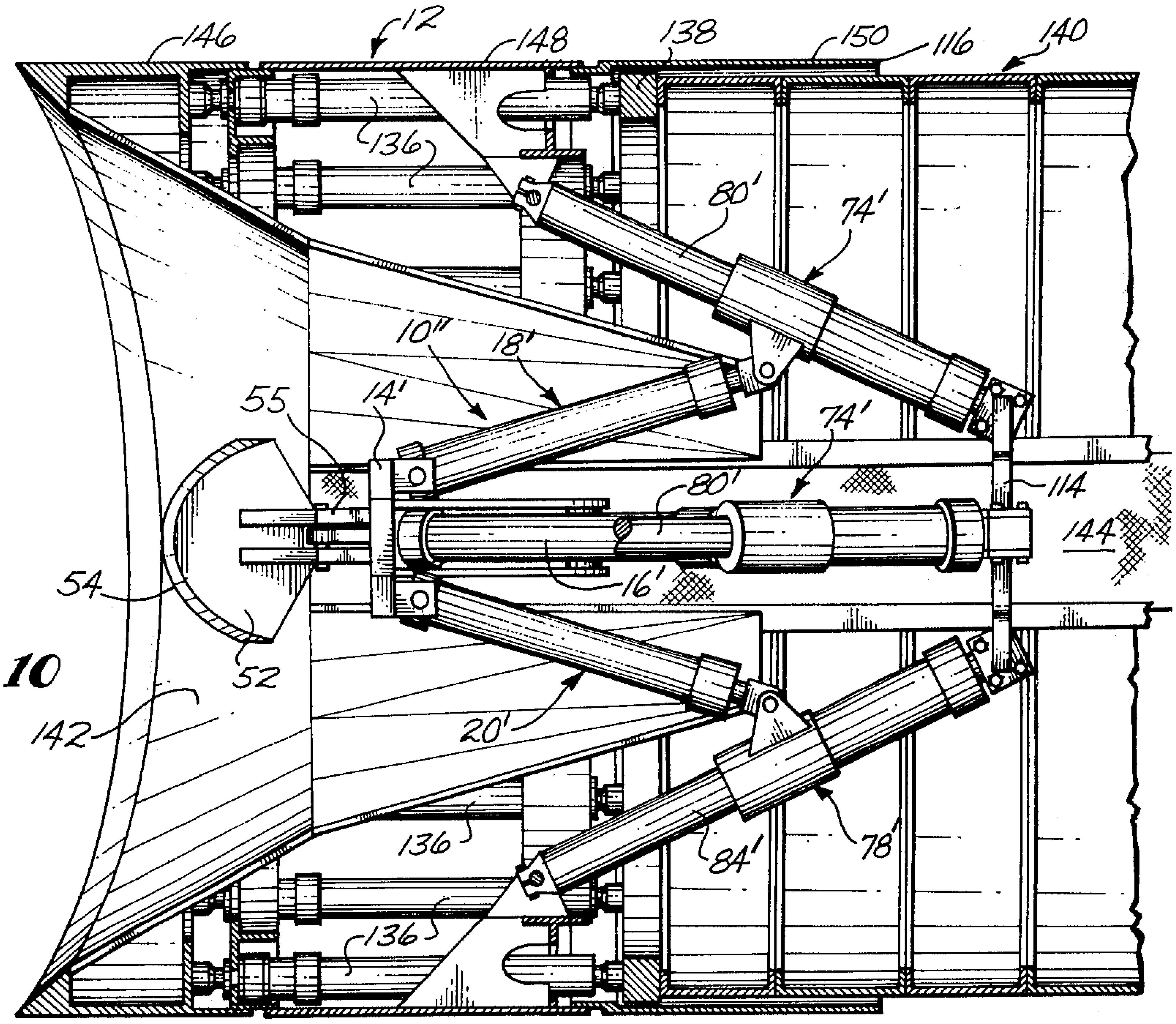

146
12
148
138
150
116
140
136
80'
74'
10''
18'
55
14'
74'
80'
114
144
54
16'
52
20'
142
136
84'
78'
136

Fig. 10

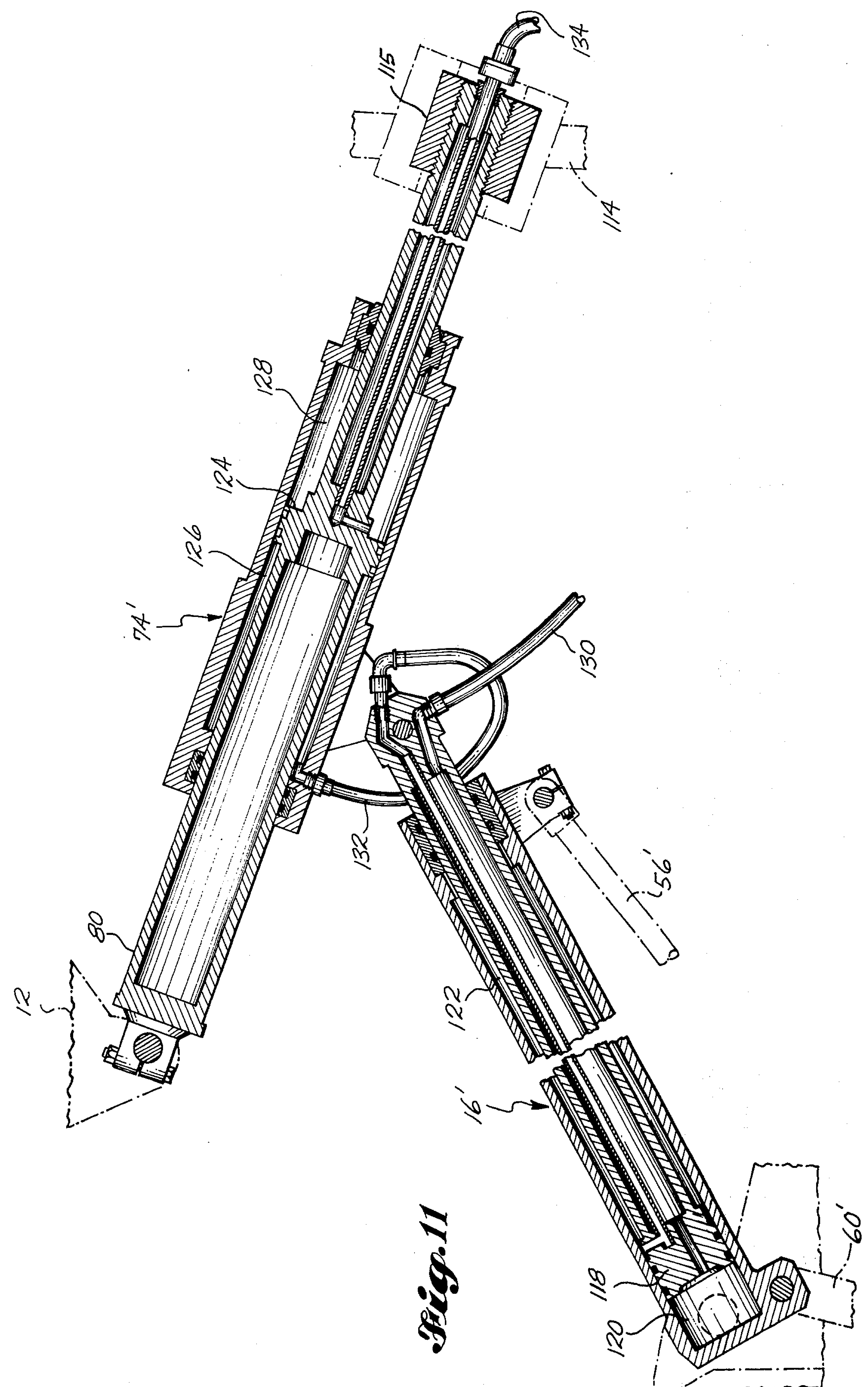


Fig.11

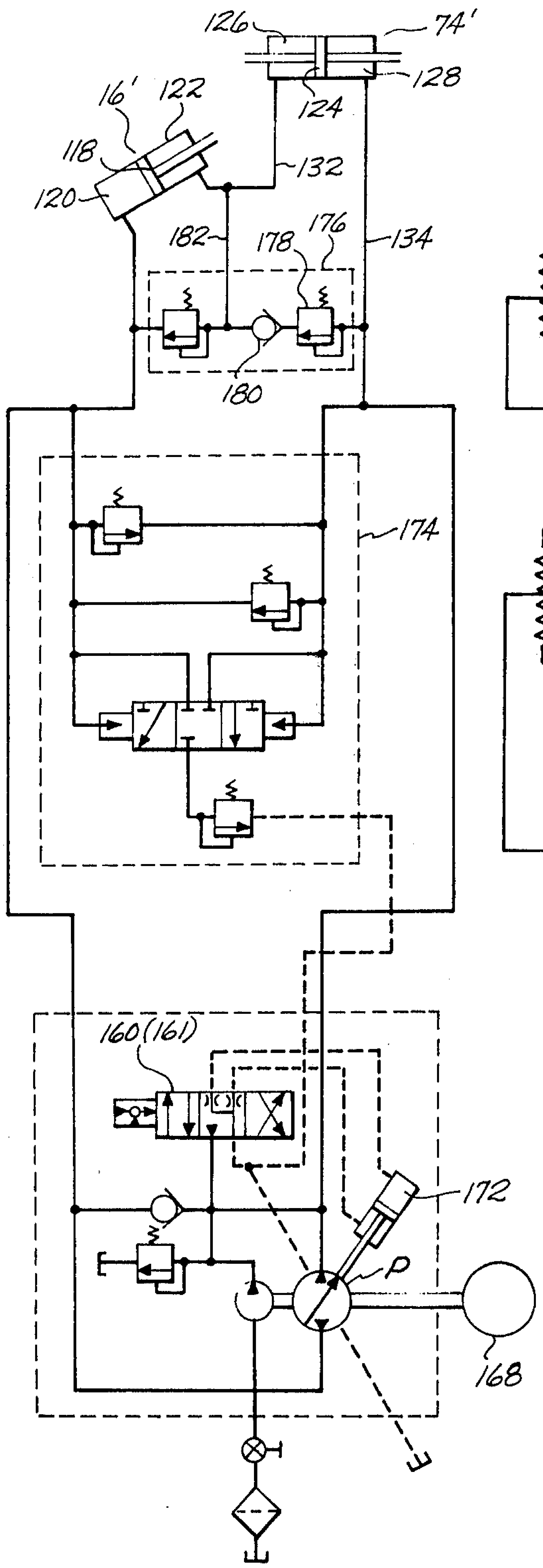

126
74'
128
124
16'
122
118
120
132
182
178
176
134
180
174
160(161)
172
P
168

Fig. 12

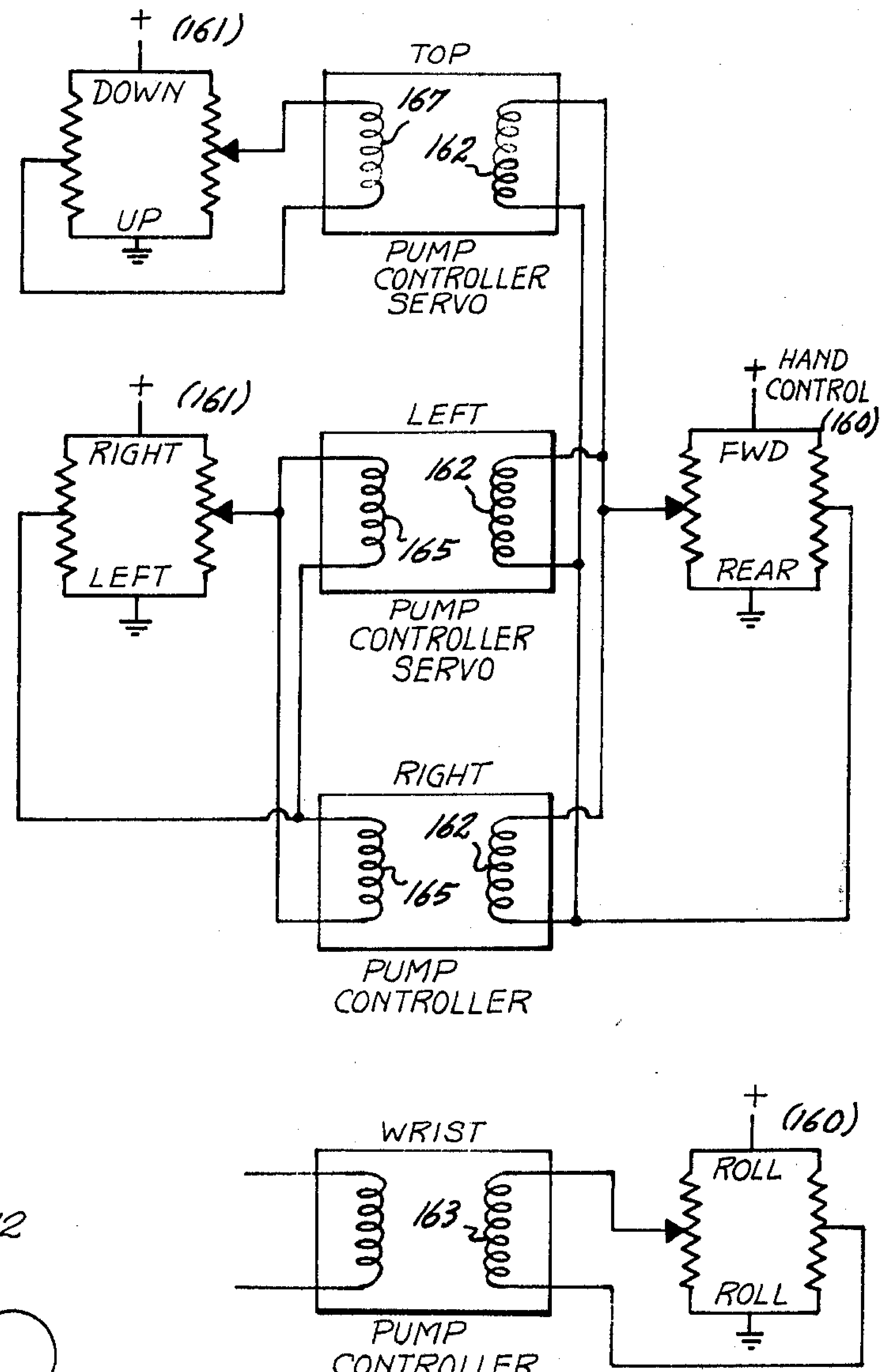

+ (161)
DOWN
UP
TOP
167
162
PUMP
CONTROLLER
SERVO
+ (161)
RIGHT
LEFT
LEFT
162
165
PUMP
CONTROLLER
SERVO
+ HAND
CONTROL
(160)
FWD
REAR
RIGHT
162
165
PUMP
CONTROLLER
WRIST
163
PUMP
CONTROLLER
+ (160)
ROLL
ROLL

Fig. 13

TUNNELING EQUIPMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to power excavating equipment and its arrangement within a tunneling shield.

2. Description of the Prior Art

The excavating equipment and tunneling machine of this invention are deemed to be improvements over the excavating equipment and tunneling machine disclosed by my U.S. Pat. No. 3,556,599, granted Jan. 19, 1971. A primary advantage of the excavating equipment of this invention is that the hydraulic cylinders which are provided for moving the cutting tool also constitutes its support structure. An overhead truck, a carriage and a boom, such as shown by my U.S. Pat. No. 3,556,599, are not needed. This results in a substantial increase in the amount of room available for the workmen or for other equipment at the head of the tunnel.

SUMMARY OF THE INVENTION

The excavating equipment of this invention is essentially characterized by a tripod type of support and drive mechanism for a cutting tool. The cutting tool is mounted onto a head portion of the tripod mechanism. The three legs of the tripod are double-acting hydraulic cylinders. The forward ends of such cylinders are connected to the head of the tripod in much the same manner that the legs of a surveyor's tripod are connected to its head, i.e. the legs are mounted for pivotal movement about the chordwise axes but the connecting means is otherwise capable of transmitting moments. The rear ends of the tripod leg forming cylinders are mounted for universal movement. Fluid is delivered to and exhausted from the cylinders for the purpose of selectively lengthening and shortening the cylinders, to in this manner, move the cutting tool in essentially all directions across the face of the tunnel.

According to one aspect of the invention, the rear ends of the tripod leg forming cylinders are connected to traveling barrel portions of three base cylinders. The base cylinders extend generally longitudinally of the tunnel and include rod portions which are fixed in position. The barrel portions of the base cylinders both move longitudinally of, and rotate about, the rods portions.

The several cylinders are selectively extended and retracted for the purpose of translating the cutting tool. The cutting tool is hinge mounted on tripod head and is movable into a position wherein its cutting edge, which may be in the nature of a wedge, is directed generally normal to the tunnel face. The several cylinders are used for thrusting the cutting tool into the tunnel face for wedging loose sections of rock or other earth material.

The cutting tool also includes a relatively large area portion and said tool is movable into a position wherein said large area portion can be used as a drag loader. With the cutting tool so positioned, the several cylinders are retracted for the purpose of drawing the cutting tool and any loose earth material in its path rearwardly to a loading mechanism.

Other aspects of the invention are hereinafter described in connection with the illustrated embodiment.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing like element designations refer to like parts, and:

FIG. 1 is an isometric view looking from above and toward the front and one side of an excavating mechanism typifying the present invention, such view showing a cutting tool approximately centered relative to a tubular tunneling shield;

FIG. 2 is a view like **FIG. 1**, but showing the cutting tool moved forwardly, upwardly and to one side of a centered position;

FIG. 3A is a diagram of the three cylinders of the support tripod shown in a common plane, and showing the relative extension of the three cylinders when the cutting tool is substantially centered as shown in **FIG. 1**;

FIG. 3B is a view like **FIG. 3A**, but showing all three cylinders extended about an equal amount, to illustrate the change in length of the cylinders which must be made for the purpose of moving the cutting tool forwardly while still centered;

FIG. 3C is a view like **FIGS. 3A** and **3B**, but showing the relative length adjustment of the three cylinders required for raising the extended tool upwardly from a substantially centered position;

FIG. 3D is a view like **FIGS. 3A – 3C**, but showing the final length adjustment of the cylinders required for swinging the extended, raised tool over to the right side of the shield;

FIG. 4 is a view like **FIG. 1**, but of a modified form of support means for the tool supporting tripod;

FIG. 5 is a fragmentary view, partially in section, showing the structural make-up of one base cylinder and one fore cylinder of the tool control mechanism of **FIG. 4**;

FIG. 6 is also a view like **FIG. 1**, but showing a third manner of supporting the support tripod for the cutting tool;

FIG. 7 is a view like **FIG. 5**, but of a related set of base and fore cylinders from the mechanism shown by **FIG. 6**;

FIG. 8 is an enlarged scale isometric view with a foreground portion cut away, taken from above and looking towards the front and one side of a shield type tunneling machine embodying the excavating mechanism of this invention, said machine being shown in conjunction with a lined portion of a tunnel immediately behind the machine, said view including a portion of a conveyor which is provided for starting movement of the cut earth rearwardly through the tunnel;

FIG. 9 is a longitudinal vertical sectional view of the embodiment of **FIG. 8**, with some parts in side elevation, said view showing the cutting tool substantially centered relative to the shield;

FIG. 10 is a longitudinal horizontal sectional view taken through the shield, with the excavating mechanism shown in top plan and in the same position that it occupies in **FIG. 9**;

FIG. 11 is a view similar to **FIG. 7**, but of the upper base cylinder and the upper fore cylinder of the mechanism shown by **FIGS. 8 – 10**;

FIG. 12 is a schematic view of the hydraulic circuit for one of the cylinder sets; and

FIG. 13 is a block diagram of a control mechanism for the three supply pumps for the three cylinder sets.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. **1** and **2**, a tool supporting tripod **10** is shown within the confines of a shield **12**, depicted by phantom lines. The tripod **10** comprises a support head **14** and three legs **16, 18, 20.** The three legs are double-acting hydraulic cylinders. The clevis-like forward ends **22, 24, 26** of the cylinders **16, 18, 20,** are pivotally attached to ear portions **28, 30, 32** of the support head **14,** by means of pivot pins **34, 36, 38,** or the like. The pivot pin joints permit relative movement about chordwise axes, i.e. the axes of pins **34, 36, 38.** Such joints are otherwise capable of transmitting moments.

Universal joints are provided at the rear end of the cylinders **16, 18, 20.** In the embodiment of FIGS. **1** and **2,** ball members, **40, 42, 44** are shown at the rear ends of the cylinders **16, 18, 20.** These ball members **40, 42, 44** are received within socket members **46, 48, 50** which are secured to sidewall portions of the shield **12.**

Since the support tripod **10** has only three legs, the centers of the pivot joints **40, 46; 42, 48** and **44, 50** by necessity lie within a common plane. Preferably, such plane is a radial plane.

The cutting tool **52** is preferably a broad blade-like member having an arcuate edge **54** which in cross-section is preferably wedge shaped. By way of typical and therefore non-limitative example, the cutting tool **52** is connected to the front end of an arm **55** that is pivotally connected to the tool support **14** for pivotal movement about an axis which extends transversely of the tunnel. A small double-acting cylinder **56** is interconnected between a rear portion **58** of tool support **14** and a control lever portion **60** shown to depend from the tool arm **55.**

In operation, hydraulic fluid is selectively introduced into and removed from the fluid chambers of the cylinders **16, 18 20,** for extending and retracting the tool support **14,** and also for moving the tool support **14** up and down and sideways.

Referring to FIG. **3A,** which shows the three cylinders **16, 18, 20** side-by-side in a common plane. Owing to the selection of the connection points for the rear ends of the cylinders **16, 18, 20** to the shield **12,** when the tool support **14** and the tool **52** carried thereby are substantially centered within the shield **12,** the two side cylinders **18, 20** are extended an equal amount and the upper cylinder **16** is extended a slightly greater amount.

Referring now to FIG. **3B,** if the operator wished to merely extend or translate the tool support **14** and the tool **52** forwardly, all three cylinders **16, 18, 20** would be further extended. If then, the operator wished to raise the tool support **14** and the tool **52,** this could be done by further extending only the two side cylinders **18, 20.** Perhaps aided by a retraction of the upper cylinder **16** (FIG. **3C**). In order to continue on to the position shown by FIG. **2,** the right side cylinder **18** is retracted a substantial amount and the upper cylinder **16** is retracted a smaller amount (FIG. **3D**). This causes a sideways movement of the tool support **14** and the tool **56** towards the right side of the shield.

The purpose of FIGS. **3A – 3D** is to diagrammatically illustrate the various relative movements of the cylinders **16, 18, 20** which are required for moving the tool **52** from the position shown in FIG. **1** to the position shown in FIG. **2.** Of course, these movements need not be performed in a step-by-step fashion as described, but in actual practice maybe combined into a single continuous step. The diagrams **3B – 3D** illustrate increments of extension or retraction of the cylinder **16, 18, 20.** In actual practice it is preferred that the increments for each are algebratically added together to obtain a single amount of extension or retraction for each cylinder **16, 18, 20** which when achieved will result in a movement of the tool **14** from its starting place to a desired new location.

The mechanism shown by FIG. **4** is essentially like the mechanism shown by FIGS. **1** and **2,** except that the rear ends of the cylinders **16, 18, 20** are pivotally connected by cross pins **62, 64, 66,** to sliding barrel portions **68, 70, 72** of three base cylinders **74, 76, 78.** In this embodiment the opposite ends of the rod portions **80, 82, 84** are connected to sidewall locations on the shield **12.** The base cylinders **74, 76, 78** are also double-acting cylinders. They extend longitudinally of the shield **12** and in parallelism with each other. The cylinder barrels **68, 70 72** are rotatable about as well as slidable along the rods **80, 82, 84.** This rotation, combined with pivotal movement about the axes **62, 64, 66,** establish a universal type mount for the rear ends of the forward or fore cylinders **16, 18, 20.** Th advantage of this arrangement over the arrangement shown by FIGS. **1** and **2** is that the position of the rear ends of the cylinders **16, 18, 20** can be moved forwardly and rearwardly, to increase the amount of translation of the tool **52.**

FIG. **5** is a longitudinal sectional view of the upper base cylinder **74** and the fore cylinder **16** paired therewith. Preferably, the other two sets of base and fore cylinders are of like construction, so they are not separately illustrated.

The front and rear ends of the rods **82** are shown to be pin connected at **86, 88** to front and rear brackets **90, 92** which are welded or otherwise secured to the shield **12.** A piston head **92** is provided on rod **82,** intermediate its ends, piston head **92** divides the interior of cylinder barrel **68** into two chambers, one on each side of the piston head **92.** The forward chamber **96** is provided with an inlet-outlet conduit **98** and the rearward chamber **100** is provided with an inlet-outlet conduit **102.** As will be evident, when fluid is introduced into chamber **100** and exhausted out from chamber **90,** the cylinder barrel **68** is moved rearwardly along rod **82.** When the direction of fluid supply and removal is reversed, cylinder barrel **68** is moved forwardly along rod **82.** The rod portion of fore cylinder **16** also includes a piston head **104** which divides the barrel portion of the cylinder **16** into front and rear chambers **106, 108.** Front chamber **106** includes an inlet-outlet conduit **110** and the rearward chamber **108** includes an inlet-outlet conduit **112.** As will be evident, when fluid is introduced into chamber **108** and removed from chamber **106,** the rod portion of the cylinder is extended and the tool support **14** is moved forwardly. When the direction of fluid flow is reversed, the rod is retracted and the tool support **14** is moved rearwardly.

The two cylinders **16, 68** may be independently operated, or may be interconnected in series, so that they always operate together, as will hereinafter be described in connection with the next embodiment.

The embodiment shown by FIG. **6** is like the embodiment shown by FIG. **4,** except that the rear ends of the rods **80, 82, 84** are not connected to a common support member **114** by a suitable moment carrying connection

115. An advantage of this arrangement is that it makes it possible to locate the rear boundary **116** of the shield **12** forwardly of the rear ends of the base cylinders **74, 76, 78** (see FIGS. **9** and **10**). When the rear ends of the base cylinder rod **80, 82, 84** are connected to the shield **12**, it makes it necesary to extend the shield rearwardly at least to the location of the rear mounts. In the embodiment shown by FIG. **6** (and by FIGS. **8 – 10**), the rear boundary **116** of the shield **12** can be located substantially forwardly of the connector member **114.**

As shown by FIG. **7**, in the embodiment of FIG. **6** the rear chamber of each fore cylinder is in fluid communication with the forward chamber of its base cylinder, i.e. the two cylinders are connected together in series. This arrangement will now be more specifically described in connection with the upper set of fore and base cylinders **16, 74.** The fore cylinder piston head **118** divides the fore cylinder barrel into a forward chamber **120** and a rearward chamber **122.** A piston head **124** on base cylinder rod **80** divides the base cylinder barrel into a forward chamber **126** and a rearward chamber **128.**

Forward chamber **120** of fore cylinder **16** is provided with an inlet-outlet conduit **130.** A transverse conduit **132** is interconnected between the rear chamber **122** of fore cylinder **16** and the forward chamber **126** of base cylinder **74.** The rear chamber **128** of base cylinder **74** is provided with an inlet-outlet conduit **134.** Now, when fluid is introduced through conduit **134** into chamber **128**, and removed from chamber **120** via conduit **130**, base cylinder **74** is moved rearwardly along rod **80.** As it moves the fluid in chamber **126** is transferred via conduit **132** into chamber **122**, causing the barrel of fore cylinder **16** to move rearwardly along the rod of such cylinder. A reversal of the flow of fluid through conduits **130, 134** causes movement of the two cylinder barrels in the opposite direction. This operation of the two cylinders **16, 74** will be discussed in greater detail in conjunction with FIGS. **12** and **13.**

FIGS. **8 – 10** show excavating equipment of the type described above in connection with FIG. **6** inside of a tunneling shield **12** which is basically like the tunneling shield disclosed by my aforementioned U.S. Pat. No. 3,556,599.

The shield **12** includes a plurality of thrust rams **136** which are double-acting hydraulic cylinders, the barrel portions of which are firmly secured to a central frame portion of the shield **12.** Thrust rams **136** include rearwardly extendible piston rods which make contact with a husky ring beam **138.**

As is conventional in the tunneling field, a tunnel lining is constructed as the tunneling machine or shield **12** is advanced forwardly. The tunnel lining **140** is continuously added onto, and extended forwardly as the shield **12** is advanced forwardly. The illustrated form of tunnel lining is composed of sectional rings which are secured together end-to-end in the tunnel. Each ring is made up of a plurality of arcuate members or sections. The ring beam **138** abuts against the forward most ring of the lining **140.** When the thrust arms **136** are extended they push rearwardly against the ring beam **138** which in turn pushes rearwardly against the immovable tunnel lining **140.** This results in the shield **12** and the excavating equipment carried thereby being moved forwardly relative to the tunnel lining **140.** After the shield **12** has been shoved forwardly an amount approximately equal to the full throw of the thrust rams **136**, the thrust rams **136** are retracted, drawing the ring beam **138** forwardly. Then, a new ring of tunnel lining is constructed ahead of the last ring, within the space existing between said last ring and the advanced ring beam **138.** As should be apparent, the shield **12** serves to support the earth material in the region where excavation is taking place and the tunnel lining supports the tunnel in its extent rearwardly of the shield **12.**

The power excavator **10''** is used for both (1) digging or mining the tunnel face and (2) drawing the mined material rearwardly and up a ramp **142** to be discharged therefrom onto an endless belt type conveyor **144**, or the like. Conveyor **144** moves such material rearwardly and deposits it into some mining cars or onto some other form of material carry-out means (e.g. another conveyor).

In operation of excavating mechanism **10''**, the several cylinders are appropriately operated for the purpose of swinging the cutting tool **52** into a desired position relative to the tunnel face. The cutting tool **52** itself is oriented so that its cutting edge **54** is directed towards the tunnel face. Then, the fore cylinders (and perhaps the base cylinders also) are extended for the purpose of forcing the cutting edge **54** into the tunnel face, causing it to split off chunks of the earth material. After a substantial amount of the earth material has accumulated at the base of the ramp **142**, the wrist piston **56'** is retracted for the purpose of swinging the flat body portion of cutting tool **52** into a loading position (the broken line position of FIG. **9**). Then, the fore and/or base cylinders are retracted for the purpose of drawing (translating) cutting tool **52** rearwardly, so that it will serve as a drag loader for the conveyor **144.**

As will be apparent, the wrist cylinder **56'** and the control linkage **60** constitute means for adjustably affixing the cutting tool **52** into two different positions, i.e. a cutting position and a loading position. The system of cylinders **16', 18', 20', 74', 76', 78'** serve to translate the cutting tool **52** forwardly towards the cutting face, serve to swing cutting tool **52** up or down and/or sideways, serve to force the cutting edge **54** into the cutting face, serve to orient the tool **52** for loading, and serve to draw the tool **52** rearwardly to cause loading.

As should be apparent, a considerable amount of work room is saved by use of the support and drive cylinder system of this invention. In the embodiment of FIGS. **8 – 10**, the space surrounding the base cylinder tripod is never occupied by any portion of the excavating mechanism, and considerable space exists inside the base cylinder tripod, as the fore cylinder tripod occupies only a relatively small amount of space.

The shield **12** is shown to include breasting doors **D** of the same general type as shown by my aforementioned U.S. Pat. No. 3,556,599. These breasting doors **D** form no part of this invention and they will not be described any further.

A tunneling machine of the present invention will have a substantially greater amount of power than the machine shown by my aforementioned U.S. Pat. No. 3,556,599 even though it possesses smaller excavating equipment. In the embodiment shown by FIGS. **8 – 10**, all six cylinders are operated together to move the tool sideways and/or up and down and to translate the tool. The cutting tool **52** is capable of breaking concrete or rock of similar hardness. When used for cutting the tool **52** is oriented to enter the face of the tunnel edgewise and hydraulic power is applied to the cylinders for forcing it endwise. Essentially axial loads are imposed on the cylinders when they are extended for the purpose of forcing the tool **52** into the tunnel face.

A valving system is required which can be operated to selectively supply and exhaust the cylinders in the same manner described for the purpose of achieving the desired function. As should be apparent, the particular valving system can vary from one installation to another.

By way of typical and therefore non-limitative example, FIGS. **12** and **13** are schematic diagrams of a control system suitable for use with the embodiment shown by FIGS. **8** – **10**. FIG. **12** is a schematic diagram of a hydraulic circuit which is provided for each fore cylinder — base cylinder set, i.e. each other fore cylinder — base cylinder set includes an identical hydraulic circuit. FIG. **13** is a schematic diagram of the control equipment for the three pumps which are included in the fore cylinder — base cylinder hydraulic circuit, and for the pump which is in the hydraulic circuit for the wrist cylinder **56'**.

Referring first to FIG. **13**, a first axis control of a two axis control mechanism **160** is shown connected to first coils **162** for the electro-hydraulic pump controllers for each pumps P. Such first axis control mechanism **160** controls forward and back movement of all cylinders simultaneously. The second axis of mechanism **160** may be connected to a controller coil **163** for the pump supplying the wrist action cylinder **56.** A first axis of a second two axis control mechanism **161** may be connected to second controller coils **165** for the two side cylinder sets with reversed polarity connection. The second axis of the mechanism **161** may be connected to the second controller coil **167** for the top cylinder set.

Referring now to FIG. **12**, one of the reversible variable displacement pumps P is shown being driven by electric motor **168.** By way of typical and therefore non-limitative example, the pump P may be of the type manufactured by Sunstrand Corp. of Ames, Ohio 50010, such as disclosed on pages 25 and 26 of such company's Bulletin No. 9582-A, dated January, 1972. Pump P includes a charge pump **170** and a control cylinder unit **172**, of the type disclosed by such bulletin. Each controller **162, 163, 165, 167** may be like a coil in the Moog electric servo controller Model 62-500.

The hydraulic circuit is preferably equipped with a main loop replenish system **174** of the type shown in combination with the variable displacement motor in the aforementioned Bulletin 9582-A. Also, it is provided with a synchronizing mechanism **176** for the fore cylinder **16'** and the base cylinder **74'**. Preferably, the volume of chamber **120** is made to equal the volume of chamber **128** and the volume of chamber **122** is made to equal the volume of **126.** During continuous operation of the excavator some leakage will occur from the chambers **122, 126.** Mechanism **176** serves to make up any lost fluid during a retraction of the cylinders. If some fluid is lost, piston **124** will bottom before piston **118.** When this happens the high pressure in line **134** will move valve **178,** allowing some of the fluid to open check valve **180** and flow through line **182** into line **132.** Once in line **132** such fluid will enter chamber **122,** finishing the stroke of piston **118** and also replacing the lost fluid.

It is to be understood that the various illustrated embodiments represent preferred embodiments and the current best mode of practicing the invention. However, it is to be understood that the physical form of the machine can vary considerably from what is shown and that the invention is composed of the features and combination of features which are set forth in the appended claims. For example, although the excavating mechanism is shown to include tripod arrangement of the cylinders, it is within the scope of this invention for a greater number of cylinders to be employed. Hence, some of the claims specify "at least three cylinders", and are to be interpreted to include three or more cylinders per mechanism. Also, although the invention has been shown in connection with a shield type tunneling machine for excavating a horizontal tunnel, the invention is not necessarily directionally oriented. This fact should be taken into consideration when interpreting the claims.

What is claimed is:

1. An excavating mechanism for use in a tunneling machine that is advanced in the tunnel as excavation proceeds, said mechanism comprising:

a cutting tool;

a support tripod for said cutting tool comprising a tool mounting head and three double-acting hydraulic cylinders forming three variable length support and drive legs, each said cylinder having a forward end and a rearward end, and means connecting the forward end of said cylinders to said mounting head for pivotal movement about chordwise axes, said means otherwise transmitting moments between said mounting head and said cylinders, said cylinders being adapted to in use diverge rearwardly from said tool mounting head, and wherein the rearward ends of said cylinders are adapted to be mounted for universal pivotal movement and said cylinders are adapted to in use be selectively extended and retracted for moving said cutting tool forwardly and rearwardly and in substantially all directions across the tunnel face; and

means mounting said cutting tool onto said tool mounting head.

2. An excavating mechanism according to claim **1,** further comprising means mounting said cutting tool onto said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for adjustably affixing the cutting tool in position relative to the tool mounting head.

3. An excavating mechanism according to claim **2,** wherein said cutting tool includes an elongated wedge-like cutting edge.

4. An excavating mechanism according to claim **1,** wherein one of the double-acting hydraulic cylinders of the support tripod occupies a central upper position and the other two double-acting hydraulic cylinders occupy side positions.

5. An excavating mechanism according to claim **4,** further comprising means mounting said cutting tool onto said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for adjustably affixing the cutting tool in position relative to the tool mounting head.

6. A tunneling machine comprising a tubular shield that is advanced in the tunnel as excavation proceeds; and

an excavating mechanism comprising:

a cutting tool;

a support tripod for said cutting tool comprising a tool mounting head and three double-acting hydraulic tool positioning cylinders forming variable length support and drive legs, each said cylinder having a forward end and a rearward end, and means connecting the forward ends of said cylinders to said mounting head for pivotal movement about chordwise axes, said means otherwise transmitting moments between said mounting head and said cylinders, with said cylinders diverging rearwardly from said tool mounting head;

means mounting said cutting tool onto said mounting head;

means mounting said support tripod onto said tubular shield including means mounting the rearward ends of said cylinders for universal pivotal movement; and

hydraulic fluid supply and return and control means for selectively extending and retracting said double-acting hydraulic cylinders, for moving said cutting tool forwardly and rearwardly and in substantially all directions across the tunnel face.

7. A tunneling machine according to claim **6**, comprising universal mounting means connecting the rearward ends of the cylinders with circumferentially spaced apart locations on said shield.

8. A tunneling machine according to claim **6**, comprising three base cylinders, each including a rod portion which is connected with said shield and a barrel portion which is both slidable along and rotatable about said rod portion, and wherein the rear end of each said tool positioning cylinder is pivotally connected to the barrel of a related base cylinder.

9. A tunneling machine according to claim **8**, wherein each tool positioning cylinder is connected in series with its base cylinder.

10. A tunneling machine according to claim **8**, wherein the rod portions of said base cylinders extend axially of the shield and in parallelism with each other.

11. A tunneling machine according to claim **8**, wherein the three base cylinders converge rearwardly and also form a tripod, and each base cylinder is a double-acting hydraulic cylinder and includes a fixed rod portion having a forward end which is connected with the shield and a rearward end, and a connector member to which the rear ends of the base cylinder rod members are attached.

12. A tunneling machine according to claim **11**, wherein the shield includes a rear boundary which terminates axially forwardly of the connector member.

13. A tunneling machine according to claim **11**, wherein each tool positioning cylinder is connected in series with its base cylinder.

14. A tunneling machine according to claim **11**, further comprising means mounting said cutting tool on said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for changing the position of said cutting tool relative to the tool mounting head.

15. An excavating mechanism according to claim **14**, wherein one of the tool positioning cylinders occupies an upper central position and the other two tool positioning cylinders occupy side positions, and said means for changing the cutting tool relative to the tool mounting head comprises a double-acting hydraulic cylinder that is interconnected between said cutting and the upper central tool positioning cylinder.

16. A tunneling machine comprising a tubular shield that is advanced in the tunnel as excavation proceeds; and

an excavating mechanism comprising:

cutting tool;

a support tripod for said cutting tool comprising a tool mounting head and three double-acting hydraulic fore cylinders forming variable length support and drive legs, each said fore cylinder having a forward end and a rearward end, and means connecting the forward ends of said fore cylinders to said mounting head for pivotal movement about chordwise axes, said means otherwise transmitting moments between said mounting head and said fore cylinders, with said fore cylinders diverging rearwardly from said tool mounting head;

three base cylinders extending generally longitudinally of the shield and each including a rod portion which is connected with said shield and a barrel portion which is both slidable along and rotatable about said rod portion;

means pivotally connecting the rearward end of each said fore cylinder to the barrel of a related base cylinder; and

control means for selectively extending and retracting said fore and base cylinders, for moving said cutting tool forwardly and rearwardly and in substantially all directions across the tunnel face.

17. A tunneling machine according to claim **16**, wherein one of the fore cylinders and a related base cylinder occupy upper central positions and the other two fore cylinders and their related base cylinders occupy side positions.

18. A tunneling machine according to claim **17**, further comprising means mounting said cutting tool on said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for adjustably affixing the cutting tool in position relative to the tool mounting head.

19. A tunneling machine according to claim **16**, wherein each fore cylinder is connected in series with its base cylinder.

20. An excavating mechanism that is advanced through the ground as excavation proceeds, said mechanism comprising:

a cutting tool;

a multipod support for said cutting tool comprising a tool mounting head and at least three double-acting hydraulic cylinders forming three variable length support and drive legs, each said cylinder having a forward end and a rearward end, and means connecting the forward ends of said cylinders to said mounting head for pivotal movement about chorwise axes, said means otherwise transmitting moments between said mounting head and said cylinders, said cylinders being adapted to in use diverge rearwardly from said tool mounting head, and wherein the rearward ends of said cylinders are adapted to be mounted for universal pivotal movement and said cylinders are selectively extended and retracted for moving said cutting tool forwardly and rearwardly and in substantially all directions across the tunnel face; and

means mounting said cutting tool onto said tool mounting head.

21. An excavating mechanism according to claim **1**, further comprising means mounting said cutting tool onto said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for adjustably affixing the cutting tool in position relative to the tool mounting head.

22. An excavating mechanism according to claim 2, wherein said cutting tool includes an elongated wedge-like cutting edge.

23. A tunneling machine comprising a tubular shield that is advanced in the tunnel as excavation proceeds; and

an excavating mechanism comprising:

a cutting tool;

a multipod support for said cutting tool comprising a tool mounting head and at least three double-acting hydraulic fore cylinders forming variable length support and drive legs, each said fore cylinder having a forward end and a rearward end, and means connecting the forward ends of said fore cylinders to said mounting head for pivotal movement about chordwise axes, said means otherwise transmitting moments between said mounting head and said fore cylinders, with said fore cylinders diverging rearwardly from said tool mounting head;

a base cylinder for each fore cylinder extending generally longitudinally of the shield and each including a rod portion which is connected with said shield and a barrel portion which is both slidable along and rotatable about said rod portion;

means pivotally connecting the rearward end of each said fore cylinder to the barrel of a related base cylinder; and

control means for selectively extending and retracting said fore and base cylinders, for moving said cutting tool forwardly and rearwardly and in substantially all directions across the tunnel face.

24. A tunneling machine according to claim 23, further comprising means mounting said cutting tool on said tool mounting head for pivotal movement about an axis which is transverse to the tunnel, and means for adjustably affixing the cutting tool in position relative to the tool mounting head.

25. A tunneling machine according to claim 23, wherein each fore cylinder is connected in series with its base cylinder.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,966,256 Dated June 29, 1976

Inventor(s) Tyman H. Fikse

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 27, the word -- cutting -- should be inserted after " arcuate " .

Column 7, line 36, the word -- an -- should be inserted before "electric".

Claim 20, line 50, the word "chorwise" should be -- chordwise --.

Claim 21, line 63, "1" should be -- 20.

Claim 22, line 1, change "2" to -- 21.

Signed and Sealed this

Tenth Day of May 1977

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks